Machinery Protection: Relays or Analog Outputs?

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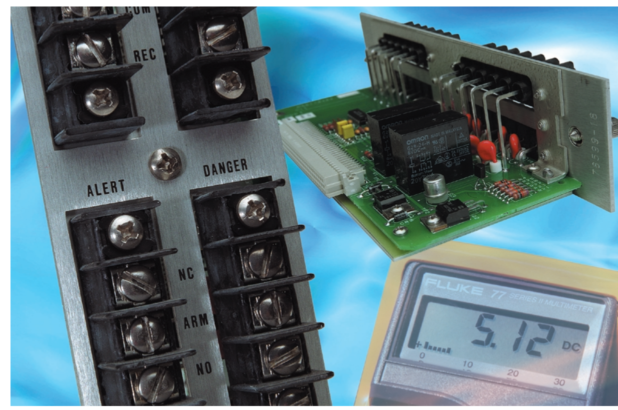

Devices that use 4 to 20 mA outputs are abundant in the process control industry and come in the form of transmitters and analog outputs from field instrumentation. They provide a standard means of interfacing measurement points to control systems to allow monitoring of simple process variables such as temperature and pressure. These process variables are typically referred to as "analog" or "static" values. They contain a single piece of information; specifically, the amplitude of the signal. For example, temperature is represented by a single parameter, the amplitude. Trending and comparison may be performed in a control or monitoring system to provide an indication of the temperature's rate of change or temperature differential, but the function of a temperature transmitter or instrument analog output is simply to convert the input signal to a proportional analog output.

Vibration signals are dynamic, not static (Figure 1). They are periodic waveforms that are made up of continuously changing values. In the case of a temperature transmitter the temperature value is derived by simply converting the voltage or resistance input, at an instant in time, to a proportional current representing that temperature. In the case of vibration, peak-to-peak (pp) or zero-to-peak (pk) amplitude values must be derived for a waveform signal using peak detection methods. An instantaneous reading of a raw vibration signal is meaningless in regards to overall amplitude.

4 to 20 mA outputs from transmitters or instrument analog outputs are restricted to transmitting a single parameter. In the case of vibration signals, there are additional parameters that can be derived from the input signal, offering significant value to machine control systems and operators. Vibration phase angle is one of these parameters. Changes in vibration phase can provide insight into many machinery faults such as mechanical imbalance or cracked shafts. Using 4 to 20 mA outputs only gives a machine control system an indication of the amplitude of vibration. The valuable phase information is not available. In the case of vibration signals derived by proximity probes (displacement transducers), there is additional information in the form of the bias voltage or gap. This gap value corresponds to the position of a rotating machine's shaft within its bearing clearance. Monitoring this gap value enables users to see machinery problems, such as misalignment or radial rubs, which cause the gap value to change. When a 4 to 20 mA output is used to interpret a vibration signal, the resulting output to a machine control system can only represent the vibration amplitude and, like the phase information, the gap value is not available to the control system or operator.

Almost all of Bently Nevada's machinery protection systems can be supplied with 4 to 20 mA analog outputs. The intent of these outputs is: (1) to drive devices like strip chart recorders or (2) to provide (with relay contacts) an analog interface mechanism for critical operations indication to older machine and plant control systems that cannot easily or economically support digital communications. *It is strongly recommended, for a number of reasons, that a protection system's relays be used rather than its analog outputs when interfacing to the machine control system.*

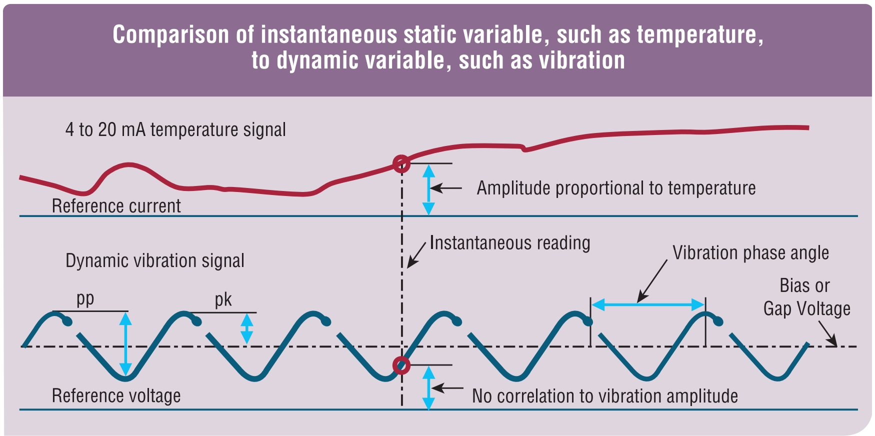

Figure 1.

potentially conflicting alarms residing in two locations – the machine control system and the machinery protection system. In this circumstance, the burden of ensuring that alarm settings match in two separate systems is introduced, along with the problem of "management of change" when alarm settings are altered.

When independent systems are being used to compare vibration readings with alarm setpoints, the two systems will usually not agree on the exact time that an alarm occurred. This can lead to a situation where one system will indicate an alarm condition and the other will not. It is particularly likely when the vibration level is hovering at or near an alarm level and the alarm delay of the machinery protection system is not in agreement with that in the machine control system.

Diagnostic and Fault Checking

The 4 to 20 mA analog outputs are not subject to the same diagnostic and fault checking as the machinery protection system and its relay outputs. Relays in the protection system have a number of features that increase the integrity of the alarms and minimize the possibility of false trips. Examples of these features include:

- Alarm time-delay
- Trip multiply
- Latching / non-latching
- Normally energized / de-energized
- Voting
- NOT OK channel (or danger) defeat
- Programmable alarm logic
- System and Relay OK status

Programmable Alarm Logic

When 4 to 20 mA outputs are used, only a single parameter is provided to the machine control system; therefore, machine protection alarms can only be based on that single parameter. Bently Nevada's machinery protection system relays are programmable, thus allowing alarming on multiple channels and parameters including channel pairs, overall amplitude, vector components (i.e., 1X amplitude and phase), gap voltage, etc. These programmable alarm features enable the relays to provide intelligent alarms to the control system, taking full advantage of the machinery protection system's functionality as well as minimizing potential false alarms.

Conflicting Alarms

The use of the machinery protection system's analog recorder outputs for machinery protection requires that the machine control system generate its own alarms, based on the levels of the analog recorder outputs. This leads to

Analog Output Accuracy

Another problem that can occur with an instrument's analog output (or in a vibration transmitter) is errors in reported vibration levels. Accuracy of these devices is typically based on the full-scale range the device is configured to use. In some applications it may be desirable to have a full-scale range far in excess of alarm setpoints. A stated accuracy of +/- 5% of full scale can result in an accuracy of +/- 25% or **more** when readings are less than half of full scale. This is primarily due to drift in analog devices and the digital-to-analog conversion that is performed to generate the 4 to 20 mA output in digital devices. The exact accuracy is dependent on the device, but in all cases accuracy is reduced when signals are below the full-scale range. Using Bently Nevada's relays eliminates this inaccuracy problem, as the signal used to derive alarms does not have an intermediate digital-to-analog conversion, and the peak detection circuitry in the monitors is not susceptible to these sources of inaccuracies.

In summary, there is strong justification to avoid the use of vibration transmitters or instrument analog outputs as inputs into machine control systems where protection system relays could otherwise be used. Although these devices serve a purpose in process variable monitoring and provide interfaces to control systems unable to accept digital communications, they have limited benefit for machinery protection.